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Ishikawa et al.

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(54) **WORK MACHINE**

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E02F 3/42 (2006.01)

(52) **U.S. Cl.**
CPC ***E02F 3/38*** (2013.01); ***E02F 3/325*** (2013.01); ***E02F 3/425*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

The invention includes a vehicle main body, a boom, a first actuator connecting the boom and the vehicle main body and configured to rotate the boom with respect to the vehicle main body about a first central axis, a first electric motor connected to the first actuator and that operates the first actuator. The boom includes a pair of boom lateral plates disposed to face each other in a direction of the first central axis, and a boom bottom plate connecting the boom lateral plates to each other, the first electric motor being disposed in a boom internal space surrounded by the pair of boom lateral plates and the boom bottom plate.

14 Claims, 6 Drawing Sheets

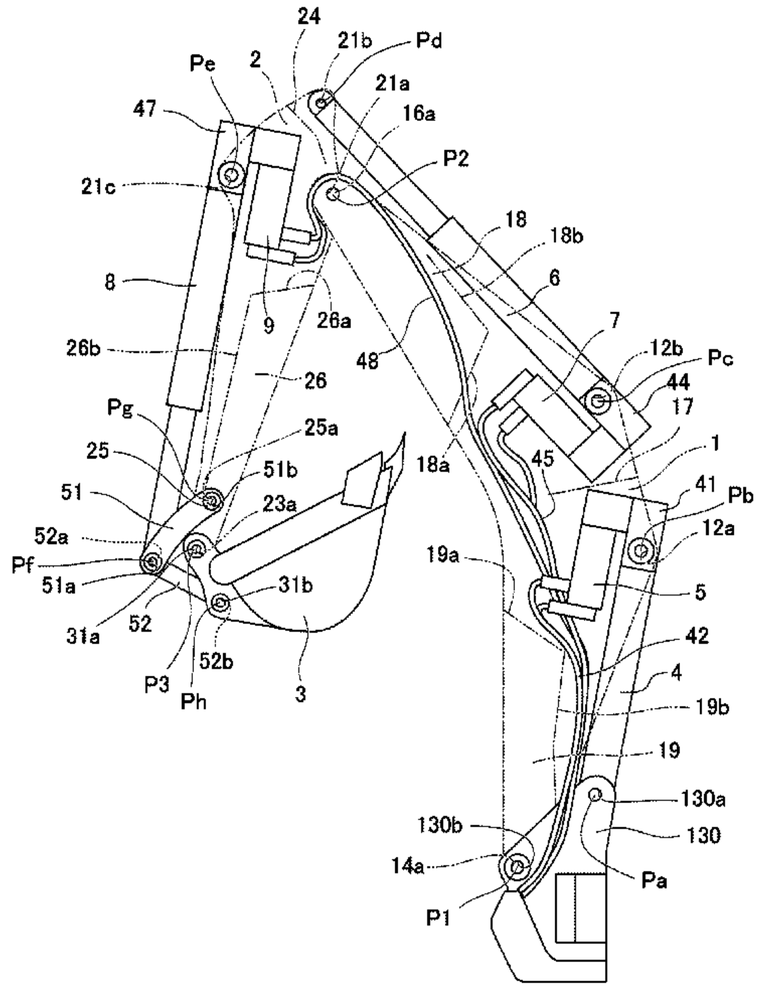

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FIG. 1

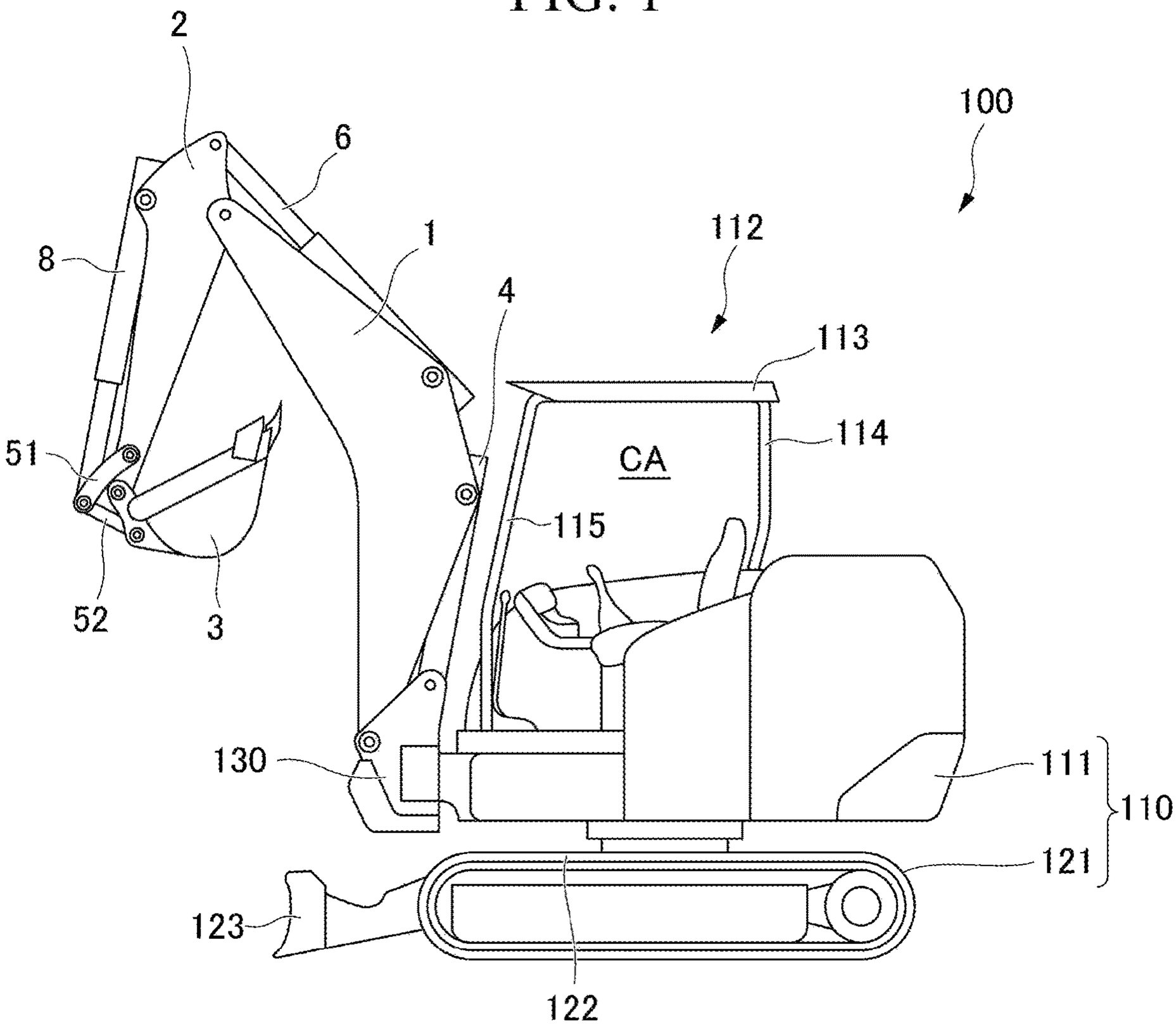
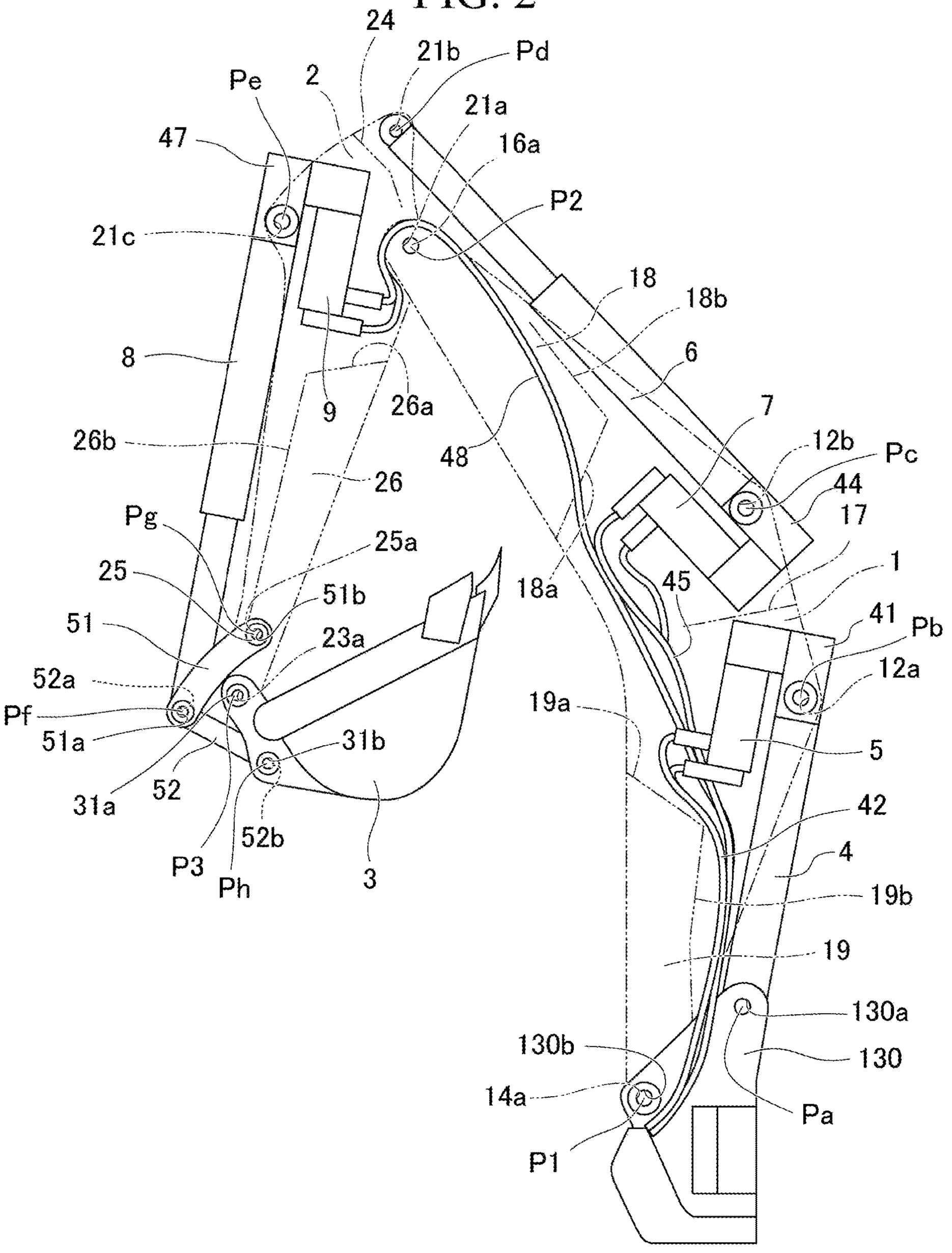


FIG. 2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12b
Pc
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18a
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51a
31b
5
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Pa
P1

FIG. 3

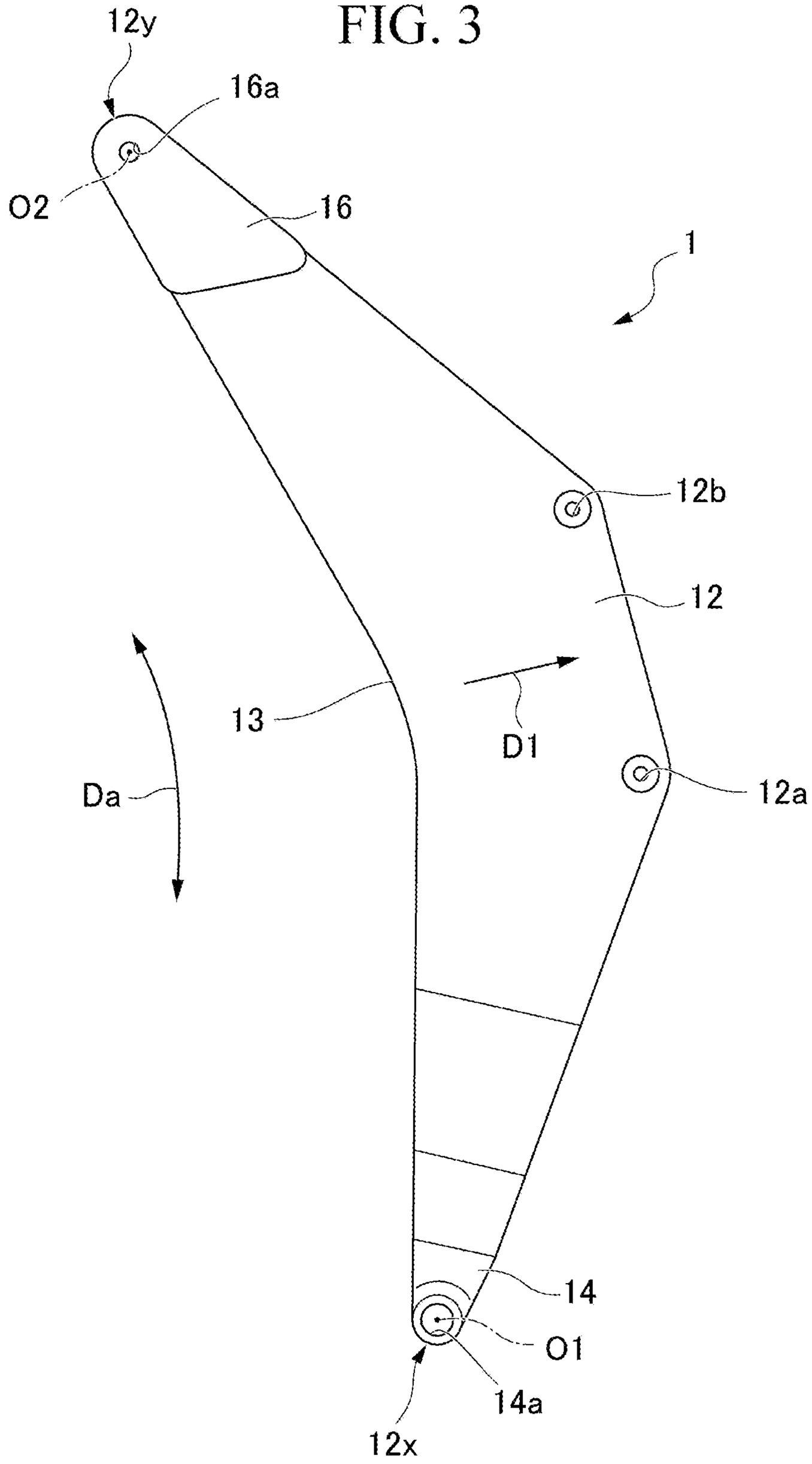
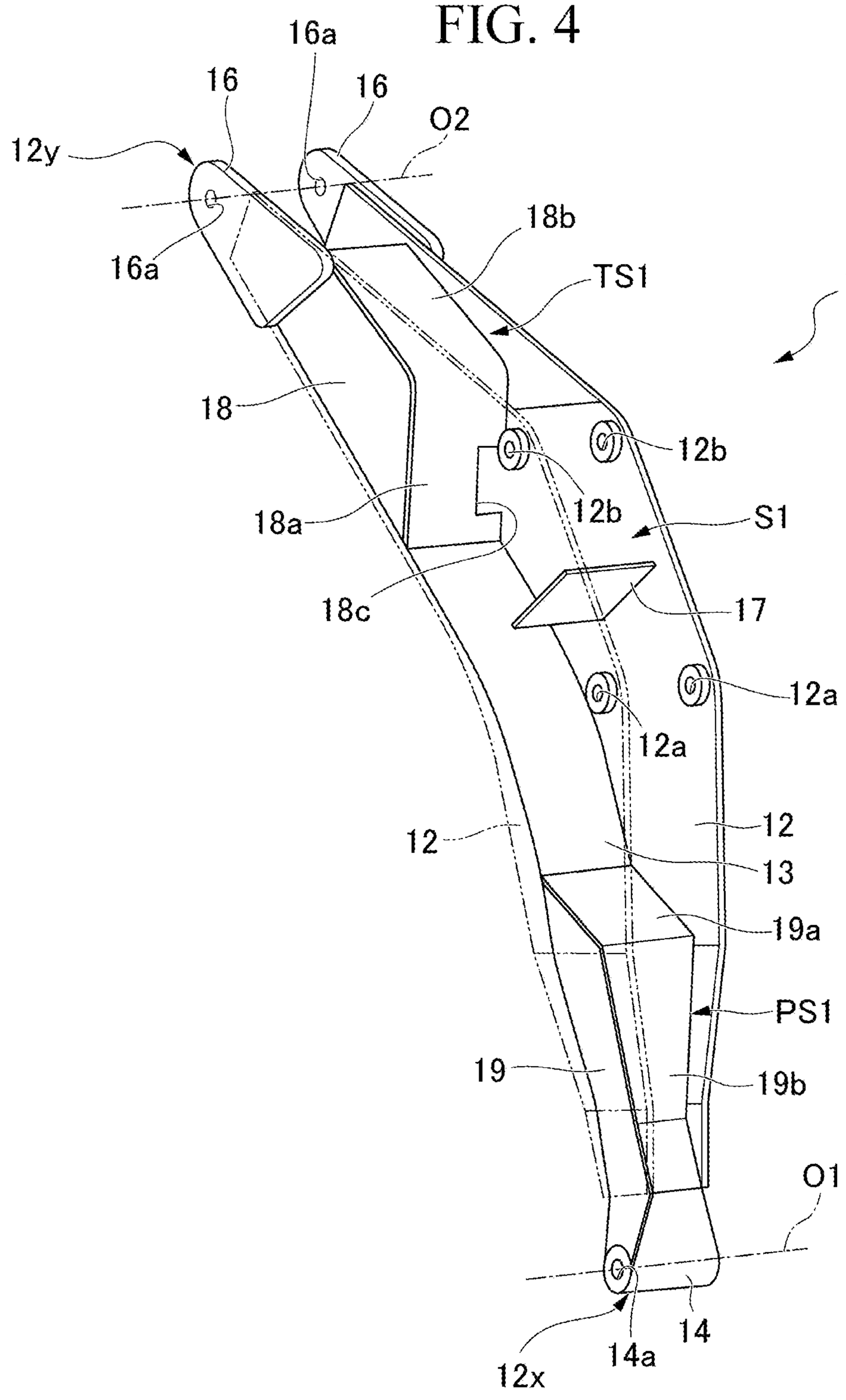


FIG. 4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16a
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12b
12b
18a
S1
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12a
12
12
13
19a
PS1
19
19b
O1
14
12x
14a

FIG. 5

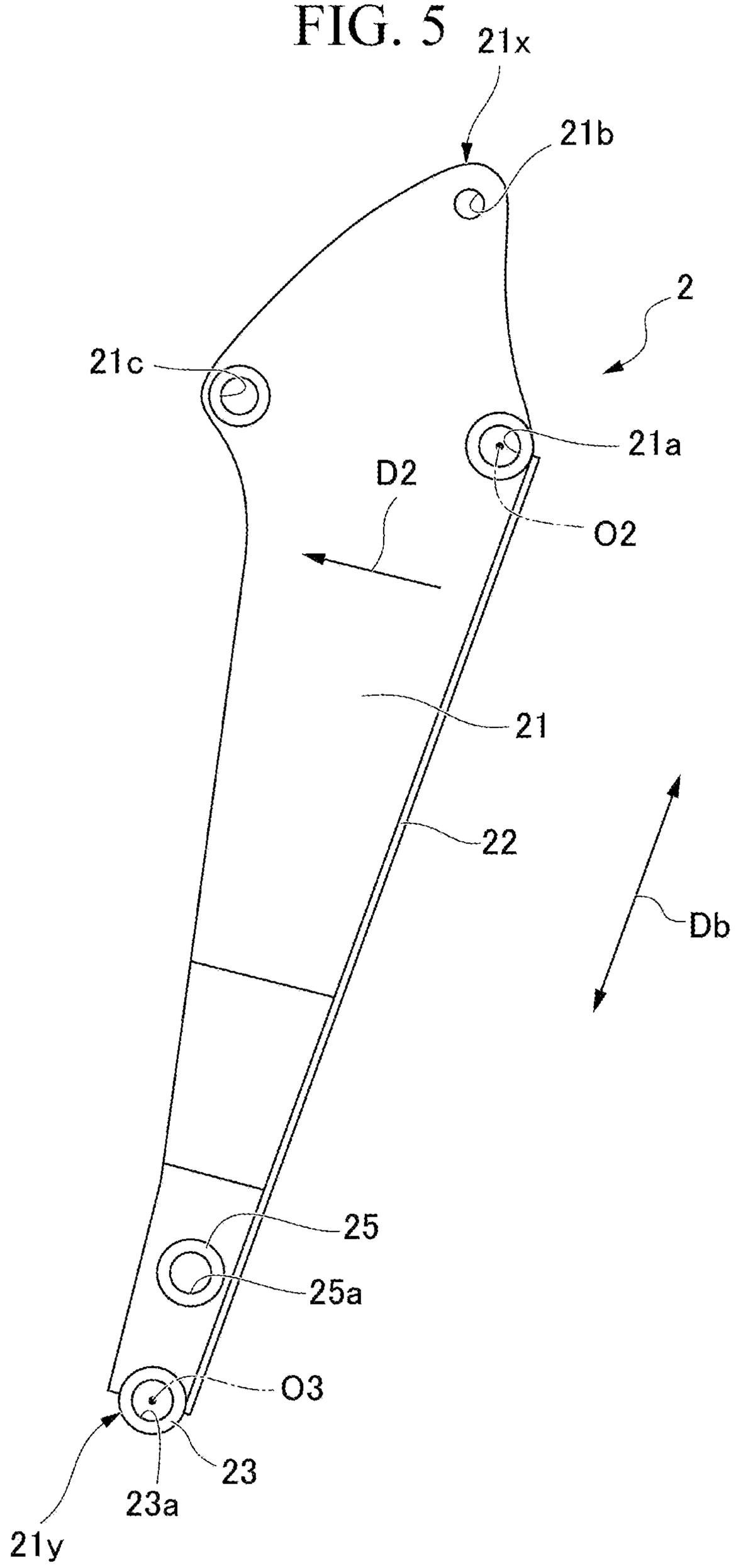
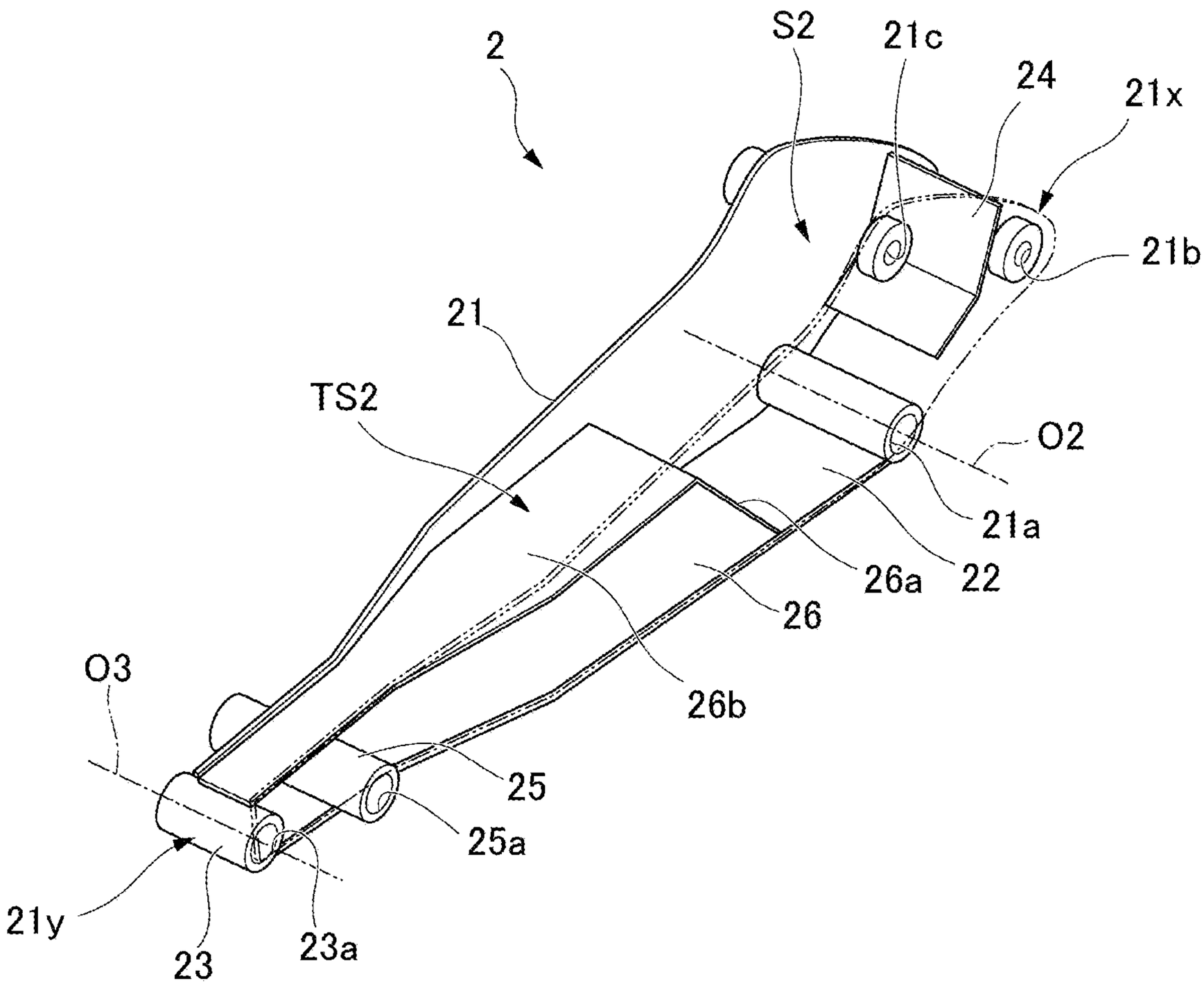


FIG. 6



WORK MACHINE

TECHNICAL FIELD

The present invention relates to a work machine.

Priority is claimed on Japanese Patent Application No. 2019-111371, filed Jun. 14, 2019, the content of which is incorporated herein by reference.

BACKGROUND ART

Patent Document 1 discloses an electric excavator as an example of a work machine. The electric excavator includes an undercarriage and an upper swing body. The upper swing body is provided with a boom, an arm, and a bucket (work tool). The boom, arm, and bucket are driven by an electric motor and an electric cylinder.

CITATION LIST

Patent Literature

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2003-82707

DISCLOSURE OF INVENTION

Technical Problem

In such a work machine, the electric motor provided in the boom is provided so as to be exposed to the outside of the boom. Therefore, the electric motor may receive an impact from the outside.

The present invention has been made in view of such a problem and the object is to provide a work machine having high reliability.

Solution to Problem

The present invention according to one aspect of the work machine includes: a vehicle main body; a boom that has a base end portion supported by the vehicle main body and that extends from the vehicle main body; a first actuator that connects the boom and the vehicle main body and is configured to rotate the boom with respect to the vehicle main body about a first central axis intersecting with an extending direction of the boom; and a first electric motor that is connected to the first actuator to operate the first actuator, wherein the boom comprises: a pair of boom lateral plates that is disposed to face each other in a direction of the first central axis; and a boom bottom plate that connects the boom lateral plates to each other, wherein the first electric motor is disposed in a boom internal space surrounded by the pair of boom lateral plates and the boom bottom plate.

Advantageous Effects of Invention

According to the work machine of the above aspect, it is possible to avoid an impact on the electric motor, and high reliability is achieved.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an entire side view of an excavator related to an embodiment of the present invention.

FIG. **2** is a side view of a boom, an arm, and a bucket of the excavator according to the embodiment of the present invention and a view showing insides of the boom and the arm in a transparent manner.

FIG. **3** is a side view of the boom of the excavator of the embodiment of the present invention.

FIG. **4** is a perspective view of the boom of the excavator according to the embodiment of the present invention and a view showing an inside of the boom in a transparent manner.

FIG. **5** is a side view of the arm of the excavator according to the embodiment of the present invention.

FIG. **6** is a perspective view of the arm of the excavator according to the present invention and a view showing an inside of the arm in a transparent manner.

EMBODIMENT FOR CARRYING OUT THE INVENTION

Hereinafter, the embodiment of present invention will be described in detail with reference to FIG. **1** to FIG. **6**.

<Excavator (Work Machine)>

As shown in the FIG. **1**, an excavator **100** as a work machine includes a vehicle main body **110**, a boom **1**, an arm **2**, and a bucket (work tool) **3**. The excavator **100** further includes a first actuator **4** and a first electric motor **5** that operate the boom **1**, a second actuator **6** and a second electric motor **7** that operate the arm **2**, and a third actuator **8** and a third electric motor **9** that operate the bucket **3**.

<Vehicle Main Body>

The vehicle main body **110** includes an undercarriage **121** and an upper swing body **111**. Hereinafter, a direction in which gravity acts in a state in which the excavator **100** is disposed in a horizontal surface is referred to as a "vertical direction".

The undercarriage **121** has a pair of right and left crawler belts **122**. For example, the undercarriage **121** is capable of traveling by driving the crawler belts **122** by an electric motor (not shown). A hydraulic motor may be used instead of the electric motor. On a front portion of the undercarriage **121**, a blade **123** as a dump plate extending in a vehicle width direction of the undercarriage **121** (hereinafter, simply referred to as a "width direction") is provided. A height position of the blade **123** is capable of being adjusted using, for example, an electric actuator.

The upper swing body **111** is the upper portion of undercarriage **121**. In the upper swing body **111**, the above-described electric motor for traveling, and a battery and an inverter serving as a power source of the electric motor for traveling are installed. The upper swing body **111** is capable of swinging about an axis extending in the vertical direction with respect to the undercarriage **121**.

The upper swing body **111** is provided with a canopy **112**. The canopy **112** forms a driving space CA. That is, the canopy **112** includes: a hood **113** that forms a ceiling portion of the driving space CA; a rear support **114** that is provided on a rear portion of the hood **113** and that extends downward from the hood **113**; and a front support **115** that is provided on a front portion of the hood **113** and that extends downward from the hood **113**. A pair of the front supports **115** and a pair of the rear supports **114** are each provided at positions separated from each other in the width direction.

Here, regardless of a traveling direction of the undercarriage **121**, a front and rear of an operator is referred to as "forward-rearward directions" of the upper swing body **111**. The vehicle width direction intersecting the forward-rearward directions is referred to as a "width direction".

As shown in FIG. **1** and FIG. **2**, a front portion of the upper swing body **111** is provided with a bracket **130** for supporting the boom **1**. As shown in FIG. **2**, the bracket **130** is provided with a first hole **130***a* extending in the width direction of the upper swing body **111** and a second hole **130***b* disposed below and in front of the first hole **130***a* and extending in parallel with the first hole **130***a*.

<Boom>

As shown in FIG. **2** to FIG. **4**, the boom **1** includes: a pair of boom lateral plates **12**; a boom bottom plate **13** that connects the pair of boom lateral plates **12**; a boom support portion **14** that supports the boom lateral plates **12** and the boom bottom plate **13** on the vehicle main body **110**; and an arm support portion **16** that is provided on each boom lateral plate **12** and that supports the arm **2**. The boom **1** further includes a boom partition member **17** that connects the pair of boom lateral plates **12** to each other.

<Boom Support Portion>

As shown in FIG. **2** to FIG. **4**, the boom support portion **14** is provided on the base end portion of the boom **1**. The boom support portion **14** is provided with a first through hole **14***a* penetrating in the width direction of the upper swing body **111**. A first pin P**1** extending in the width direction is inserted into the first through hole **14***a*. A rotation center of the first pin P**1** is defined as a first central axis O**1**. The first pin P**1** is inserted into the second hole **130***b* of the bracket **130** of the vehicle main body **110**; thereby the boom support portion **14** is supported so as to be rotatable about the first central axis O**1** with respect to the upper swing body **111**.

<Boom Lateral Plate>

As shown in FIG. **4**, the pair of boom lateral plates **12** are disposed to face each other at an interval in the direction of the first central axis O**1**, that is, in the width direction of the upper swing body **111**. In addition, as shown in FIG. **3**, each boom lateral plate **12** has a shape in which a size (plate width size) in a vertically provided direction from the boom bottom plate **13** gradually increases and then gradually decreases from a base end portion **12***x*, which is a base end portion of the boom **1**, toward a tip end portion **12***y*, which is the tip end portion of the boom **1**. Therefore, the plate width size is largest at a center portion of the boom lateral plate **12** in an extending direction Da. In addition, the both boom lateral plates **12** extend in parallel to each other from the base end portion **12***x* toward the tip end portion **12***y* as shown in FIG. **4**, then bend or curve so as to separate from each other, then bend or curve so as to approach each other, and finally extend in parallel to each other toward the center portion in the extending direction Da and the tip end portion **12***y*.

The base end portion **12***x* of the pair of boom lateral plates **12** are provided integrally with the boom support portion **14**, so that each boom lateral plate **12** extends so as to separate from the boom support portion **14**.

<Arm Support Portion>

As shown in FIG. **4**, the arm support portions **16** are arranged to face each other at intervals in the direction of the first central axis O**1**, that is, in the width direction of the upper swing body **111**. Each of the arm support portions **16** has a plate shape.

As shown in FIG. **3** and FIG. **4**, the arm support portion **16** is provided on the tip end portion **12***y* of the boom lateral plate **12**. The pair of arm support portions **16** are provided on an outer surface of each boom lateral plate **12** so as to sandwich the pair of boom lateral plates **12**. Each of the arm support portions **16** is provided so as to protrude in the extending direction Da of the boom lateral plate **12** from the tip end portion **12***y* of each boom lateral plate **12**. A portion

of the arm support portion **16** protruding from the boom lateral plate **12** is provided with a second through hole **16***a* penetrating in the width direction of the upper swing body **111**. A second pin P**2** extending in the width direction is inserted into the second through hole **16***a*. A rotation center of the second pin P**2** is defined as a second central axis O**2**.

<Boom Bottom Plate>

The boom bottom plate **13** has a plate shape as shown in FIG. **4**. The boom bottom plate **13** is provided along the extending direction Da of the boom lateral plate **12**. As shown in FIG. **3** and FIG. **4**, the boom bottom plate **13** connects the pair of boom lateral plates **12**. To be specific, the pair of boom lateral plates **12** are provided integrally with the boom bottom plate **13** at both edge portions of the boom bottom plate **13** in the direction in which the first central axis O**1** extends, that is, in the width direction. In a state in which the entire boom **1** is disposed along the vertical direction, the boom lateral plate **12** is erected from the boom bottom plate **13** toward the upper swing body **111** side. Hereinafter, a direction in which the boom lateral plate **12** is erected from the boom bottom plate **13** is referred to as a first direction D**1**. The first direction D**1** is a direction intersecting with the extending direction Da. The boom bottom plate **13** is bent or curved so as to be convex toward the first direction D**1** at a central portion in the extending direction Da.

As shown in FIG. **4**, from the boom bottom plate **13**, a tip end convex portion **18** is provided, which protrudes in the vertically provided direction of the boom lateral plates **12**, that is, in the first direction D**1**, on a tip end portion **12***y* side of the boom lateral plate **12**, and connects the pair of boom lateral plates **12** to each other. The tip end convex portion **18** is provided integrally with the boom bottom plate **13** and the boom lateral plate **12** by joining a member having a plate shape to the boom bottom plate **13** and the boom lateral plate **12** by welding or the like. Therefore, the tip end convex portion **18** is provided on the boom bottom plate **13** so as to be sandwiched by the pair of boom lateral plates **12**.

As shown in FIG. **4**, the tip end convex portion **18** is provided with an inclination surface **18***a* at a position close to the central portion in the extending direction Da in the boom bottom plate **13**, and the inclination surface **18***a* is inclined toward the tip end portion **12***y* of the boom lateral plate **12** while separating away from the boom bottom plate **13** in the first direction D**1**. The tip end convex portion **18** further includes an upper surface **18***b* having a flat shape, being bent or curved from the inclination surface **18***a*, and continuously directed to the tip end portion **12***y*.

The upper surface **18***b* of the tip end convex portion **18** is disposed on a side closer to the boom bottom plate **13** than an upper edge portion of the boom lateral plate **12**, that is, an edge portion on a side away from the boom bottom plate **13** in the first direction D**1**. As a result, a tip end-side space TS**1** is formed on the first direction D**1** side of the upper surface **18***b* by being sandwiched by the upper surface **18***b* of the tip end convex portion **18** and the pair of boom lateral plates **12**. In the tip end convex portion **18**, a passage **18***c* penetrating in an extending direction of the boom **1** and opening to an inclination surface **18***a* is provided at a position adjacent to one boom lateral plate **12**.

Further, from the boom bottom plate **13**, a base end convex portion **19** is provided which protrudes in the first direction D**1** on the base end portion **12***x* side of the boom lateral plate **12** and connects the pair of boom lateral plates **12** to each other. Therefore, the base end convex portion **19** is provided on the boom bottom plate **13** so as to be sandwiched by the pair of boom lateral plates **12**.

As shown in FIG. **4**, the base end convex portion **19** is provided with an inclination surface **19***a* at a position close to the central portion in the extending direction Da in the boom bottom plate **13**, and the inclination surface **19***a* is inclined toward the base end portion **12***x* of the boom lateral plate **12** while separating away from the boom bottom plate **13** in the first direction D**1**. The base end convex portion **19** further includes an upper surface **19***b* having a flat shape, being bent or curved from the inclination surface **19***a*, and continuously directed to the base end portion **12***x*. The upper surface **19***b* is disposed on a side closer to the boom bottom plate **13** than the upper edge portion of the boom lateral plate **12**, that is, an edge portion on a side away from the boom bottom plate **13** in the first direction D**1**. As a result, a base end-side space PTS**1** is formed on a first direction D**1** side of the upper surface **19***b* by being sandwiched by the upper surface **19** of the base end convex portion **19** and the pair of boom lateral plates **12**.

Here, a space that is surrounded by the boom bottom plate **13** and the pair of boom lateral plates **12** and that is formed on the first direction D**1** side of the boom bottom plate **13** between the inclination surface **18***a* of the tip end convex portion **18** and the inclination surface **19***a* of the base end convex portion **19** is defined as a boom internal space S**1**. The boom internal space S**1** is disposed at a central portion in the extending direction Da of the boom lateral plate **12**.

<Boom Partition Member>

The boom partition member **17** has a plate shape as shown in FIG. **4**. The boom partition member **17** is disposed in the boom internal space S**1** and connects the pair of boom lateral plates **12** to each other. Specifically, the boom partition member **17** is provided at a position separated from the boom bottom plate **13**, and partitions the boom internal space S**1** in the middle of the extending direction Da. A first actuator hole **12***a* and a second actuator hole **12***b* that penetrate in the width direction of the upper swing body **111** at positions close to the upper edge portion in each of the pair of boom lateral plates **12** are provided on both sides in the extending direction Da with the boom partition member **17** being sandwiched therebetween.

The first actuator hole **12***a* is provided closer to the base end portion **12***x* side of the boom lateral plate **12** than the second actuator hole **12***b*. Central axes of the first actuator hole **12***a* and the second actuator hole **12***b* are provided in parallel with central axes of the first through hole **14***a* and the second through hole **16***a*.

<Arm>

As shown in FIG. **2**, FIG. **5**, and FIG. **6**, the arm **2** includes: a pair of arm lateral plates **21** extending in a direction away from the arm support portion **16** of the tip end portion **12***y* of the boom lateral plate **12**; an arm bottom plate **22** connecting the pair of arm lateral plates **21** to each other; and a work tool support portion **23** provided on the arm lateral plates **21** and supporting the bucket **3** as a work tool. The arm **2** further includes an arm partition member **24** that connects the pair of arm lateral plates **21** to each other.

<Arm Lateral Plate>

As shown by FIG. **5** and FIG. **6**, the pair of arm lateral plates **21** are arranged to face each other at an interval in the direction of the second central axis O**2**, that is, in the width direction of the upper swing body **111**. The arm lateral plate **21** extends in a direction (extending direction Db) away from the tip end portion of the boom **1**. A base end portion **21***x* of the pair of arm lateral plates **21**, which is on the tip end portion side of the boom **1**, is provided with a boom connection hole **21***a* penetrating in the width direction of the upper swing body **111**. The boom connection hole **21***a* is provided at a position adjacent to the arm bottom plate **22**. The second pin P**2** is inserted into the boom connection hole **21***a*.

As shown in FIG. **5**, an actuator connection hole **21***b* penetrating in the width direction of the upper swing body **111** is provided at a position closer to an upper edge portion of the arm lateral plate **21** than the boom connection hole **21***a*, that is, an edge portion on a side away from the arm bottom plate **22**, and further on the base end portion **21***x* side of the arm lateral plate **21** than the boom connection hole **21***a*. In parallel with the actuator connection hole **21***b*, a third actuator hole **21***c* penetrating the arm lateral plate **21** in the width direction of the upper swing body **111** is provided. The third actuator hole **21***c* is provided at a position close to the upper edge portion of the arm lateral plate **21** with respect to the boom connection hole **21***a*.

In each arm lateral plate **21**, a size in a vertically provided direction from the arm bottom plate **22** (a plate width size) gradually increases from a position where the actuator connection hole **21***b* of the base end portion **21***x* is provided toward the tip end portion **21***y*, and then gradually decreases. The boom connection hole **21***a* and the third actuator hole **21***c* are provided at a position where the plate width size is the largest in the arm lateral plate **21**.

As shown in FIG. **2**, the pair of arm lateral plates **21** are sandwiched by the pair of arm support portions **16**, and the second pin P**2** is inserted into the boom connection hole **21***a* and the second through hole **16***a*; thereby the pair of arm lateral plates **21** is supported by the arm support portions **16** in the boom **1**. As a result, the arm **2** is rotatable about the second central axis O**2** with respect to the boom **1**.

<Work Tool Support Portion>

As shown in FIG. **5** and FIG. **6**, the work tool support portion **23** is provided to be disposed between the pair of arm lateral plates **21** on the tip end portion **21***y* of the arm lateral plate **21**. The work tool support portion **23** is provided with a third through hole **23***a* penetrating in the width direction of the upper swing body **111**. A third pin P**3** extending in the width direction is inserted into the third through hole **23***a*. A rotation center of the third pin P**3** is referred to as a third central axis O**3**. Adjacent to the third through hole **23***a*, a link support portion **25** is provided closer to the base end portion **21***x* side of the arm lateral plate **21** than the third through hole **23***a* so as to protrude in a direction away from each of the pair of arm lateral plates **21**. The link support portion **25** is provided with a first link connection hole **25***a* extending in parallel with the third through hole **23***a*.

<Arm Bottom Plate>

The arm bottom plate **22** has a flat plate shape as shown in FIG. **5** and FIG. **6**. The arm bottom plate **22** connects the pair of arm lateral plates **21** to each other. Specifically, the pair of arm lateral plates **21** are provided integrally with the arm bottom plate **22** at both edge portions of the arm bottom plate **22** in the direction in which the third central axis O**3** extends, that is, in the width direction. The arm bottom plate **22** is provided along the extending direction Db of the arm lateral plate **21**. In a state in which the entire arm **2** is disposed along the vertical direction, the arm lateral plate **21** is vertically provided from the arm bottom plate **22** in a direction away from the upper swing body **111**. Hereinafter, a direction in which the arm lateral plate **21** is vertically provided from the arm bottom plate **22** is referred to as a second direction D**2**. The second direction D**2** is a direction intersecting the extending direction Db.

As shown in FIG. **6**, from the arm bottom plate **22**, a tip end convex portion **26** which protrudes in the vertically

provided direction of the arm lateral plate **21**, that is, in the second direction D**2**, on the tip end portion **21***y* side of the arm lateral plate **21**, and connects the pair of arm lateral plates **21** to each other is provided to be across from a central portion in the extending direction Db of the arm lateral plate **21** to the tip end portion **21***y*. The tip end convex portion **26** is provided integrally with the arm bottom plate **22** and the arm lateral plates **21** by joining a plate-shaped member to the arm bottom plate **22** and the arm lateral plates **21** by welding or the like. Therefore, the tip end convex portion **26** is provided on the arm bottom plate **22** so as to be sandwiched by the pair of arm lateral plates **21**.

As shown in FIG. **6**, the tip end convex portion **26** is provided with an inclination surface **26***a* at a position close to the center portion in the extending direction Db of the arm lateral plate **21** and the inclination surface **26***a* is inclined toward the tip end portion **21***y* of the arm lateral plate **21** while separating away in the second direction D**2** from the arm bottom plate **22**. The tip end convex portion **26** further includes an upper surface **26***b* having a flat shape, being bent or curved, and being continuous from the inclination surface **26***a*. The upper surface **26***b* is disposed on a side closer to the arm bottom plate **22** than the upper edge portion of the arm lateral plate **21**, that is, an edge portion on a side away from the arm bottom plate **22** in the second direction D**2**. As a result, a tip end-side space TS**2** is formed on the second direction D**2** side of the upper surface **26***b*, being sandwiched by the upper surface **26***b* of the tip end convex portion **26** and the pair of arm lateral plates **21**.

Here, a space that is surrounded by the arm bottom plate **22** and the pair of arm lateral plates **21** and formed on the second direction D**2** side of the arm bottom plate **22** between the inclination surface **26***a* of the tip end convex portion **26** and the arm partition member **24** is referred to as an arm internal space S**2**.

<Arm Partition Member>

The arm partition member **24** has a plate shape as shown in FIG. **6**. As shown in FIG. **2** and FIG. **6**, the arm partition member **24** connects the pair of arm lateral plates **21** to each other. The arm partition member **24** is provided at a position separated from the arm bottom plate **22**, and partitions the arm internal space S**2** in the middle of the extending direction Db. The arm partition member **24** has a V-letter plate shape that extends so as to direct toward the base end portion **21***x* of the arm lateral plate **21** while separating away from the arm bottom plate **22** and then to be bent or curved to the tip end portion **21***y* side while directing toward the base end portion **21***x* (see FIG. **2**).

<Bucket>

The bucket **3** as the work tool is provided with a work tool through hole **31***a* penetrating in the width direction of the upper swing body **111** as shown in FIG. **1** and FIG. **2**. Further, the bucket **3** is provided with a second link connection hole **31***b* extending in parallel with the work tool through hole **31***a* at a position adjacent to the work tool through hole **31***a* and away from the tip end portion **21***y* of the arm lateral plate **21** with respect to the work tool through hole **31***a*.

The third pin P**3** is inserted into the work tool through hole **31***a* together with the third through hole **23***a* of the work tool support portion **23** in the arm **2**; thereby the bucket **3** is supported so as to be rotatable about the third central axis O**3** with respect to the arm **2**.

<First Actuator>

The first actuator **4** has a rod shape that expands and contracts along an extending direction of the boom **1** as shown in FIG. **2**. Although not shown in detail, the first actuator **4** has a structure using, for example, a ball screw. A first end of the first actuator **4** is connected to the first hole **130***a* of the bracket **130** by a pin Pa, and is supported by the upper swing body **111** via the bracket **130** so as to be rotatable about a central axis extending in the width direction of the upper swing body **111** with respect to the bracket **130**.

A second end of the first actuator **4** is connected to the first actuator hole **12***a* of the boom **1** by a pin Pb, and is supported by the boom **1** so as to be rotatable about a central axis extending in the width direction of the upper swing body **111** with respect to the boom **1**. As a result, the first actuator **4** is disposed closer to the base end portion **12***x* side of the boom lateral plate **12** than the boom partition member **17**.

<First Electric Motor>

The first electric motor **5** is provided adjacent to the first actuator **4** as shown in FIG. **2**, and operates the first actuator **4** using the above-described battery as a power source. By operating the first actuator **4** by the first electric motor **5**, the first actuator **4** expands and contracts and the boom **1** rotates around the central axis O**1** with respect to the upper swing body **111** of the vehicle main body **110**.

In the present embodiment, the first electric motor **5** is disposed at a position closer to the boom bottom plate **13** than the first actuator **4**, and is disposed between the boom bottom plate **13** and the first actuator **4**. The first electric motor **5** is disposed in the boom internal space S**1**. A first power transmission mechanism **41** using, for example, a planetary gear mechanism or a pulley is provided between the first electric motor **5** and the first actuator **4**.

In the present embodiment, the first power transmission mechanism **41** is provided at the second end of the first actuator **4**, and the first electric motor **5** is disposed on the second end side of the first actuator **4**. A wiring **42** extends from the first electric motor **5**. The wiring **42** extends along the inclination surface **19***a* and the upper surface **19***b* of the base end convex portion **19** of the boom **1**, and is connected to a power source (not shown) provided in the upper swing body **111** through an inside of the bracket **130**. Therefore, the wiring **42** is disposed in the boom internal space S**1** and the base end-side space PS**1**. Here, the first electric motor **5** is always disposed in the boom internal space S**1** regardless of a posture of the boom **1**. The first electric motor **5** and the wiring **42** are disposed closer to the base end portion **12***x* side of the boom lateral plate **12** than the boom partition member **17**.

<Second Actuator>

The second actuator **6** has a configuration similar to that of the first actuator **4** as shown in FIG. **2**. A first end of the second actuator **6** is connected to the second actuator hole **12***b* of the boom **1** by a pin Pc, and is supported by the boom **1** so as to be rotatable about the central axis extending in the width direction of the upper swing body **111** with respect to the boom **1**.

A second end of the second actuator **6** is connected to the actuator connection hole **21***b* of the arm **2** by a pin Pd, and is supported by the arm **2** so as to be rotatable around a central axis extending in the width direction of the upper swing body **111** with respect to the arm **2**. Thus, the second actuator **6** is disposed closer to the tip end portion **12***y* side of the boom lateral plate **12** than the boom partition member **17**.

<Second Electric Motor>

The second electric motor **7** has a configuration similar to that of the first electric motor **5**, is provided adjacent to the second actuator **6** as shown in FIG. **2**, and operates the second actuator **6** using the above-described battery as a

power source. By operating the second actuator **6** by the second electric motor **7**, the second actuator **6** expands and contracts and the arm **2** rotates about the second central axis with respect to the boom **1**.

In the present embodiment, the second electric motor **7** is disposed at a position closer to the boom bottom plate **13** than the second actuator **6**, and is disposed between the boom bottom plate **13** and the second actuator **6**. The second electric motor **7** is disposed in the boom internal space S**1**. A second power transmission mechanism **44** is provided between the second electric motor **7** and the second actuator **6**. The second power transmission mechanism **44** has the same configuration as the first power transmission mechanism **41**.

In the present embodiment, the second power transmission mechanism **44** is provided at the first end of the second actuator **6**, and the second electric motor **7** is disposed on the first end side of the second actuator **6**. A wiring **45** extends from the second electric motor **7**. The wiring **45** extends toward the first electric motor **5** along the inclination surface **19***a* and the upper surface **19***b* of the base end convex portion **19** of the boom **1** together with the wiring **42** of the first electric motor **5**, and is connected to a power source (not shown) provided in the upper swing body **111** through the inside of the bracket **130**. Therefore, the wiring **45** is disposed in the boom internal space S**1** and the base end-side space PS**1**. Here, the second electric motor **7** is always disposed in the boom internal space S**1** regardless of the posture of the arm **2**. The second electric motor **7** and the wiring **45** are disposed closer to the tip end portion **12***y* side of the boom lateral plate **12** than the boom partition member **17**, and the second electric motor **7** and the first electric motor **5** are provided at positions close to each other in the boom internal space S**1**.

<Third Actuator>

As shown in FIG. **2**, the third actuator **8** has the same configuration as the first actuator **4** and the second actuator **6**. A first end of the third actuator **8** is connected to the third actuator hole **21***c* of the arm **2** by a pin Pe. Therefore, the third actuator **8** is supported by the arm **2** so as to be rotatable about the central axis extending in the width direction of the upper swing body **111** with respect to the arm **2**.

A first link member **51** is provided at a second end of the third actuator **8**. A first link through hole **51***a* penetrating in the width direction of the upper swing body **111** is provided at the first end of the first link member **51**. The second end of the third actuator **8** is connected to the first link through hole **51***a* by a pin Pf. Therefore, the third actuator **8** supports the first link member **51** so as to be rotatable about a central axis extending in the width direction of the upper swing body **111** with respect to the first link member **51**.

The second end of the first link member **51** is provided with a second link through hole **51***b* penetrating in the width direction of the upper swing body **111**. The second link through hole **51***b* is connected to the first link connection hole **25***a* of the arm **2** by a pin Pg. Therefore, the first link member **51** is supported by the arm **2** so as to be rotatable about the central axis extending in the width direction of the upper swing body **111** with respect to the arm **2**.

The third actuator **8** is provided with a second link member **52**. A third link through hole **52***a* penetrating in the width direction of the upper swing body **111** is provided at the first end of the second link member **52**. The third link through hole **52***a* is connected to the second end of the third actuator **8** and the first link through hole **51***a* by a pin Pf. Therefore, the second link member **52** is provided so as to be rotatable about a central axis extending in the width direction of the upper swing body **111** with respect to the second end of the third actuator **8** and the first link member **51**.

Further, the second end of the second link member **52** is provided with a fourth link through hole **52***b* penetrating in the width direction of the upper swing body **111**. The fourth link through hole **52***b* is connected to the second link connection hole **31***b* of the bucket **3** by a pin Ph. Therefore, the second link member **52** is provided so as to be rotatable about a central axis extending in the width direction of the upper swing body **111** with respect to the bucket **3**. The third actuator **8** is disposed closer to the tip end portion **21***y* side of the arm lateral plate **21** than the arm partition member **24**.

<Third Electric Motor>

The third electric motor **9** has the same configuration as the first electric motor **5** and the second electric motor **7**, is provided adjacent to the third actuator **8** as shown in FIG. **2**, and operates the third actuator **8** using the above-described battery as a power source. By operating the third actuator **8** by the third electric motor **9**, the third actuator **8** expands and contracts and the bucket **3** rotates about the central axis O**3** with respect to the arm **2** by the first link member **51** and the second link member **52**.

In the present embodiment, the third electric motor **9** is disposed at a position closer to the arm bottom plate **22** than the third actuator **8**, and is disposed between the arm bottom plate **22** and the third actuator **8**. The third electric motor **9** is disposed in the arm internal space S**2**. A third power transmission mechanism **47** is provided between the third electric motor **9** and the third actuator **8**. The third power transmission mechanism **47** has the same configuration as the first power transmission mechanism **41** and the second power transmission mechanism **44**.

In the present embodiment, the third power transmission mechanism **47** is provided at the first end of the third actuator **8**, and the third electric motor **9** is disposed on the first end side of the third actuator **8**. A wiring **48** extends from the third electric motor **9**. The wiring **48** extends toward the boom **1** and passes through a passage **18***c* shown in FIG. **4** and provided in the tip end convex portion **18** of the boom **1**. Further, the wiring **48** extends toward the first electric motor **5** and the second electric motor **7** along the inclination surface **19***a* and the upper surface **19***b* of the base end convex portion **19** of the boom **1** together with the wirings **42** and **45** of the first electric motor **5** and the second electric motor **7**, and is connected to a power source (not shown) provided in the upper swing body **111** through the inside of the bracket **130**. Therefore, the wiring **48** is disposed in the boom internal space S**1** and the base end-side space PS**1**. Here, the third electric motor **9** is always disposed in the arm internal space S**2** regardless of the posture of the bucket **3**. The third electric motor **9** and the wiring **48** are disposed closer to the tip end portion **21***y* side of the arm lateral plate **21** than the arm partition member **24**.

<Operation and Effects>

In the excavator **100** having the above-described configuration, the first electric motor **5** is disposed in the boom internal space S**1**. That is, the first electric motor **5** is provided so as to be surrounded between the pair of boom lateral plates **12** and boom bottom plate **13**. Therefore, the first electric motor **5** is not exposed from the boom **1**.

As a result, it is possible to prevent the first electric motor **5** from receiving an impact when the excavator **100** is performing work, to continue the work, and to stably operate the excavator **100**. Therefore, the reliability of the excavator **100** is improved.

Similarly, the second electric motor **7** is disposed in the boom internal space S**1**. Therefore, the second electric motor **7** is not exposed from the boom **1**, and it is possible to prevent the second electric motor **7** from receiving an impact when the excavator **100** is performing work, thus improving the reliability of the excavator **100**.

The third electric motor **9** is disposed in the arm internal space S**2**. That is, the third electric motor **9** is provided so as to be surrounded between the pair of arm lateral plates **21** and the arm bottom plate **22**. Therefore, the third electric motor **9** is not exposed from the arm **2**, and it is possible to prevent the third electric motor **9** from receiving an impact when work is performed by the excavator **100**, thus improving the reliability of the excavator **100**.

Since the first electric motor **5** is disposed between the boom bottom plate **13** and the first actuator **4**, the first electric motor **5** can be protected by the first actuator **4**. As a result, an impact on the first electric motor **5** can be further avoided.

Similarly, since the second electric motor **7** is disposed between the boom bottom plate **13** and the second actuator **6**, the second electric motor **7** can be protected by the second actuator **6**. As a result, an impact on the second electric motor **7** can be further avoided.

Since the third electric motor **9** is disposed between the arm bottom plate **22** and the third actuator **8**, the third electric motor **9** can be protected by the third actuator **8**. As a result, an impact on the third electric motor **9** can be further avoided.

In addition, the first electric motor **5** and the second electric motor **7** are both disposed in the boom internal space S**1**. As a result, the first electric motor **5** and the second electric motor **7** are provided so as to be close proximity in the central portion in the extending direction of the boom **1**. Therefore, maintenance of the first electric motor **5** and the second electric motor **7** can be performed in one place, and maintainability can be improved.

Further, since the boom partition member **17** is provided so as to connect the pair of boom lateral plates **12**, the strength of the boom **1** can be improved. That is, the vertically provided size of the boom lateral plate **12** from the boom bottom plate **13** (the size in the first direction D**1**) is the largest at the central portion in the extending direction Da; however, deflection of the boom lateral plate **12** can be suppressed by providing the boom partition member **17** at that position.

Similarly, since the arm partition member **24** is provided so as to connect the pair of arm lateral plates **21**, the strength of the arm **2** can be improved.

Other Embodiment

Although the embodiment of the present invention has been described above, the present invention is not limited thereto and can be appropriately changed without departing from the technical idea of the invention.

For example, the boom **1** may further include a top plate disposed to face the boom bottom plate **13** and connecting the pair of boom lateral plates **12** to each other. In this case, the boom **1** has a box shape with a cover, and the boom internal space S**1** is surrounded by the boom bottom plate **13**, the boom lateral plates **12**, and the top plate, on the left, right, top and bottom thereof. In this case, since the first electric motor **5** and the second electric motor **7** are also surrounded from the vertically provided direction of the boom lateral plate **12**, it is possible to further avoid an impact on the first electric motor **5** and the second electric motor **7**.

Similarly, the arm **2** may further include a top plate disposed to face the arm bottom plate **22** and connecting the pair of arm lateral plates **21** to each other. In this case, the arm **2** has a box shape with a cover, and the arm internal space S**2** is surrounded by the boom bottom plate **13**, the boom lateral plates **12**, and the top plate, on the left, right, top and bottom thereof. In this case, since the third electric motor **9** is also surrounded from the vertically provided direction of the arm lateral plate **21**, it is possible to further avoid an impact on the third electric motor **9**.

The position of the first electric motor **5** and the position of the first actuator **4** may be reversed. That is, the first actuator **4** may be provided so as to be sandwiched between the first electric motor **5** and the boom bottom plate **13**. The position of the second electric motor **7** and the position of the second actuator **6** may be reversed, and the position of the third electric motor **9** and the position of the third actuator **8** may be reversed. The third electric motor **9** may be exposed from the arm **2**.

In embodiment, the excavator **100** has been described as an example of a work machine, but the present invention is not limited thereto. For example, the invention according to the present embodiment may be applied to a crane or a pipe layer that does not include the arm **2**. In addition, although an example in which the bucket **3** is provided in the arm **2** has been described as an example of the work tool, the invention according to the present embodiment may be applied to the excavator **100** in which a crushing tool, a cutting machine, or the like is provided in the arm **2** instead of the bucket **3**.

INDUSTRIAL APPLICABILITY

According to the work machine of present invention, an impact to the electric motor can be avoided and high reliability is achieved.

REFERENCE SIGNS LIST

1: Boom
2: Arm
3: Bucket
4: First Actuator
5: First Electric Motor
6: Second Actuator
7: Second Electric Motor
8: Third Actuator
9: Third Electric Motor
12: Boom Lateral Plate
12*a*: First Actuator Hole
12*b*: Second Actuator Hole
12*x*: Base End Portion
12*y*: Tip End Portion
13: Boom Bottom Plate
14: Boom Support Portion
14*a*: First Through Hole
16: Arm Support Portion
16*a*: Second Through Hole
17: Boom Partition Member
18: Tip End Convex Portion
18*a*: Inclination Surface
18*b*: Upper Surface
18*c*: Passage
19: Base End Convex Portion

19*a*: Inclination Surface
19*b*: Upper Surface
21: Arm Lateral Plate
21*a*: Boom Connection Hole
21*b*: Actuator Connection Hole
21*c*: Third Actuator Hole
21*x*: Base End Portion
21*y*: Tip End Portion
22: Arm Bottom Plate
23: Work Tool Support Portion
23*a*: Third Through Hole
24: Arm Partition Member
25: Link Support Portion
25*a*: First Link Connection Hole
26: Tip End Convex Portion
26*a*: Inclination Surface
26*b*: Upper Surface
31*a*: Work Tool Through Hole
31*b*: Second Link Connection Hole
41: First Power Transmission Mechanism
42: Wiring
44: Second Power Transmission Mechanism
45: Wiring
47: Third Power Transmission Mechanism
48: Wiring
51: First Link Member
51*a*: First Link Through Hole
51*b*: Second Link Through Hole
52: Second Link Member
52*a*: Third Link Through Hole
52*b*: Fourth Link Through Hole
100: Excavator
110: Vehicle Main Body
111: Upper Swing Body
112: Canopy
113: Hood
114: Rear Portion Support
115: Front Portion Support
121: Undercarriage
122: Crawler
123: Blade
130: Bracket
130*a*: First Hole
130*b*: Second Hole
O**1**: First Central Axis
O**2**: Second Central Axis
O**3**: Third Central Axis
S**1**: Boom Internal Space
S**2**: Arm Internal Space
PS**1**: Base End-Side Space
TS**1**: Tip End-Side Space
TS**2**: Tip End-Side Space
P**1**: First Pin
P**2**: Second Pin
P**3**: Third Pin
Pa, Pb, Pc, Pd, Pf, Pg, Ph: Pin
CA: Driving Space
D**1**: First Direction
D**2**: Second Direction
Da: Extending Direction
Db: Extending Direction

The invention claimed is:

1. A work machine, comprising:

a vehicle main body;

a boom that has a base end portion supported by the vehicle main body and that extends from the vehicle main body;

a first actuator that connects the boom and the vehicle main body and is configured to rotate the boom with respect to the vehicle main body about a first central axis intersecting with an extending direction of the boom; and

a first electric motor that is connected to the first actuator to operate the first actuator,

wherein the boom comprises:

a pair of boom lateral plates that is disposed to face each other in a direction of the first central axis; and

a boom bottom plate that connects the boom lateral plates to each other,

wherein the first electric motor is disposed in a boom internal space surrounded by the pair of boom lateral plates and the boom bottom plate,

wherein the first electric motor is disposed between the boom bottom plate and the first actuator,

wherein a tip end portion of the boom is provided with a tip end convex portion that protrudes from the boom bottom plate and connects the pair of boom lateral plates,

wherein the base end portion of the boom is provided with a base end convex portion that protrudes from the boom bottom plate and connects the pair of boom lateral plates,

wherein the boom internal space is formed between the tip end convex portion and the base end convex portion,

wherein the tip end convex portion is provided with a first inclination surface and a first upper surface, the first inclination surface being inclined toward a tip end portion of the boom lateral plate while separating away from the boom bottom plate, the first upper surface having a flat shape, being bent or curved from the first inclination surface, and continuously directed to the tip end portion of the boom lateral plate,

wherein the first upper surface of the tip end convex portion is disposed closer to the boom bottom plate than an upper edge portion of the boom lateral plate,

wherein the base end convex portion is provided with a second inclination surface and a second upper surface, the second inclination surface being inclined toward a base end portion of the boom lateral plate while separating away from the boom bottom plate, the second upper surface having a flat shape, being bent or curved from the second inclination surface, and continuously directed to the base end portion of the boom lateral plate, and

wherein the second upper surface of the base end convex portion is disposed closer to the boom bottom plate than an upper edge portion of the boom lateral plate.

2. The work machine according to claim **1**, further comprising:

an arm that is supported by the tip end portion of the boom and that extends from the tip end portion;

a second actuator that connects the boom and the arm and is configured to rotate the arm about a second central axis intersecting with an extending direction of the arm; and

a second electric motor that is configured to operate the second actuator,

wherein the second electric motor is disposed in the boom internal space.

3. The work machine according to claim **2**,

wherein the second electric motor is disposed between the boom bottom plate and the second actuator.

4. The work machine according to claim 3, further comprising:
a work tool supported by the arm;
a third actuator that connects the work tool and the arm and is configured to rotate the work tool about a third central axis intersecting with an extending direction of the arm; and
a third electric motor configured to operate the third actuator,
wherein the arm includes
a pair of arm lateral plates arranged to face each other in a direction of the third central axis, and
an arm bottom plate connecting the arm lateral plates to each other,
wherein the third electric motor is disposed in an arm internal space surrounded by the pair of arm lateral plates and the arm bottom plate.

5. The work machine according to claim 3,
wherein the first actuator has a first end connected to the vehicle main body and a second end connected to the boom, and
the second actuator has a first end connected to the boom and a second end connected to the arm,
wherein the first electric motor is disposed on the second end side of the first actuator, and
the second electric motor is disposed on the first end side of the second actuator.

6. The work machine according to claim 5,
wherein the tip end portion of the boom is provided with a tip end convex portion that protrudes from the boom bottom plate and connects the pair of boom lateral plates,
the base end portion of the boom is provided with a base end convex portion that protrudes from the boom bottom plate and connects the pair of boom lateral plates, and
the boom internal space is formed between the tip end convex portion and the base end convex portion.

7. The work machine according to claim 3,
wherein the boom further includes a partition member that connects the pair of boom lateral plates to each other and partitions the boom internal space portion in the middle in the extending direction of the boom.

8. The work machine according to claim 2, further comprising:
a work tool supported by the arm;
a third actuator that connects the work tool and the arm and is configured to rotate the work tool about a third central axis intersecting with an extending direction of the arm; and
a third electric motor configured to operate the third actuator,
wherein the arm includes
a pair of arm lateral plates arranged to face each other in a direction of the third central axis, and
an arm bottom plate connecting the arm lateral plates to each other,
wherein the third electric motor is disposed in an arm internal space surrounded by the pair of arm lateral plates and the arm bottom plate.

9. The work machine according to claim 8,
wherein the first actuator has a first end connected to the vehicle main body and a second end connected to the boom, and
the second actuator has a first end connected to the boom and a second end connected to the arm,
wherein the first electric motor is disposed on the second end side of the first actuator, and
the second electric motor is disposed on the first end side of the second actuator.

10. The work machine according to claim 8,
wherein the boom further includes a partition member that connects the pair of boom lateral plates to each other and partitions the boom internal space portion in the middle in the extending direction of the boom.

11. The work machine according to claim 2,
wherein the first actuator has a first end connected to the vehicle main body and a second end connected to the boom, and
the second actuator has a first end connected to the boom and a second end connected to the arm,
wherein the first electric motor is disposed on the second end side of the first actuator, and
the second electric motor is disposed on the first end side of the second actuator.

12. The work machine according to claim 11,
wherein the boom further includes a partition member that connects the pair of boom lateral plates to each other and partitions the boom internal space portion in the middle in the extending direction of the boom.

13. The work machine according to claim 2,
wherein the boom further includes a partition member that connects the pair of boom lateral plates to each other and partitions the boom internal space portion in the middle in the extending direction of the boom.

14. The work machine according to claim 1,
wherein the boom further includes a partition member that connects the pair of boom lateral plates to each other and partitions the boom internal space portion in the middle in the extending direction of the boom.

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